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TRANSFER AND DEVELOPMENT OF TECHNOLOGY IN A CHANGING WORLD ENVIRONMENT: THE CHALLENGES OF THE 1990s

Report by the UNCTAD secretariat

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CONTENTS

		Paragraphs
Executive summary		(i)-(ix)
Introduction		1-3
Chapter		
I.	**Global environment for the transfer and development of technology**	**4-40**
	A. Trends in technology flows	4-12
	1. Dimensions and direction	4-8
	2. Financial constraints	9-12
	B. Selected global developments	13-40
	1. Emergence of new technologies	14-18
	2. New directions in intellectual property rights protection and inter-firm technological linkages	19-23
	3. Technology and sustainable development	24-25
	4. Evolution in international trade relations	26-40
II.	**Technological dynamism: contrasting national experiences among developing countries**	**41-78**
	A. Introduction	41-44
	B. The basis of technological dynamism	45-50
	C. Indicators of technological dynamism	51-53
	D. Explaining contrasting experiences	54-76
	E. Implications of past experience	77-78
III.	**Conclusion**	**79-85**

EXECUTIVE SUMMARY

(i) Prospects for technology transfer, technological development and economic growth in the developing countries in the 1990s depend not only on domestic but also increasingly on external forces, both of which are addressed in this report. A review of trends in technology flows in the second half of the 1980s reveals continued growth in the relative importance of capital goods trade and foreign direct investment among developed market-economy countries, an acceleration of such flows to a small number of countries in developing Asia and only modest improvement compared with the first half of the decade in their rate of growth in real terms to the majority of developing countries. Adverse financial constraints have outweighed the effects of favourable legislation in the attempt to attract foreign investment and technology and have contributed to a growing inability of many developing countries to keep up with technological developments that will be required in order to maintain or achieve international competitiveness.

(ii) Technological advances in the developed market-economy countries and a number of recent economic and political developments of international scope also have varying implications for the competitiveness of developing countries' exports and for the transfer and development of technology in the coming years. The diffusion of innovations in biotechnology, the production and use of new materials and computerization present both challenges and opportunities for developing countries. Inter-country differences in the existing industrial, scientific and technological base and in the ability to attract foreign investment and technology inflows suggest the strong possibility that these changes will increase the industrial and technological polarization between developed and developing countries, as well as among developing countries themselves. In the face of growing R and D costs and intensified international technological competition, companies in developed market-economy countries have sought to protect their technological innovations by securing greater government enforcement of intellectual property rights protection. Related considerations, including the possibility of exploiting economies of scale and complementarities in R and D, have led these companies to forge strategic alliances with competitors, customers and suppliers, chiefly in other developed countries. Effects of these trends on the cost of and access to technology for developing countries are expected to be of particular importance in certain industries (e.g., pharmaceuticals, chemicals and semi-conductors), whereas in most other industries technology may continue to be readily available from alternative sources for the majority of developing countries.

(iii) A major challenge for the world community in the 1990s and beyond is how to elaborate and implement a strategy for sustainable development. The application of environmentally sound technologies can contribute significantly to raising the productivity and sustainability of resources in such areas as agricultural production, renewable energy production and pollution control. There is a need to accelerate technology transfer and development in order to increase the skill and knowledge base upon which environmentally sound production decisions are made.

(iv) The strong interdependence between export growth, technological change and economic development gives developing countries an important stake in the outcome of attempts to liberalize trade and strengthen the rules governing international trade relations. Of particular concern are the three technology-related reforms that have been put forward in various international fora. Taken together, the uniform imposition of stricter standards of intellectual property rights enforcement, restriction of performance requirements on investment and (possibly) opening up of developing countries' services sectors before they are on a competitive footing could affect developing countries' technological and economic development prospects by limiting significantly the policy options at their disposal in promoting the dynamism of their industrial and services sectors.

(v) The completion of the single EEC market in 1992 will affect the transfer of and investment in technology in developing countries. In the short to medium term, it will do so chiefly by diverting investment and other technology flows from countries exporting manufactures to the EEC, in order to take advantage of economies of scale and other forms of improved efficiency from operation within the EEC market and to circumvent potential trade barriers affecting future exports to the market. The changes taking place in Eastern Europe will also affect technology-related flows to developing countries during the 1990s, not so much because this part of the world will be competing with developing countries for these flows, but because of the economic impact on developing countries of the likely diversion of aid flows and some possible increase, however small, in global interest rates.

(vi) As in the recent past, national policies interacting with global economic forces are likely to play an important role in determining the pace of industrialization, technological development and economic performance in the 1990s. Taking into account different starting positions, as well as different exogenous influences on development, there remains considerable variation in the efficiency with which developing countries have carried out industrialization over the last four decades. An essential component of efficient industrialization is technological dynamism, defined as the ability to absorb and efficiently deploy new technologies, adapt them to local conditions, improve upon them and ultimately create new knowledge. Technological dynamism at the national level is the result of a synergy between enterprise capabilities, incentives and institutions. Mere possession of skills is a necessary, but not sufficient, condition for industrial success. This point is borne out by the experience of Eastern Europe, where there has long existed an ample stock of human capital and technical skills, but where lack of market-based incentives, combined with institutional weaknesses and isolation from world technologies, led to poor industrial performance. While human resources may not be the binding constraint in the industrialization of some (mainly Latin American) countries, they do constitute major impediments to development in others (mainly sub-Saharan countries).

(vii) A review of several indicators of industrial and technological performance of 29 developing countries for 1970-1988 reinforces the impression of dynamism in the more advanced economies of East Asia (Hong Kong, Republic of Korea, Singapore and Taiwan Province of China) and to a lesser extent in some of the newly industrializing countries, such as Indonesia, Malaysia and Thailand. The lessons that can be drawn from their experience suggest that 'export orientation' does not constitute a uniform set of policies, nor does it necessarily carry non-interventionist connotations. Two major elements -- the incentive structure in product markets and intervention in factor markets -- form an integral part of the policy package employed by successful exporters. Even among the more advanced economies of East Asia a wide range of strategies have been followed, although all have commonly been labeled export-oriented. Thus, Hong Kong has come closest to a laissez-faire approach, whereas the Republic of Korea has resorted to some typically import-substituting measures, though very selectively and for a limited period (i.e. the 'infant industry' period). Although both economies are successful and competitive, the resulting industrial structures are vastly different.

(viii) The interpretation of industrial success, relying heavily on 'getting prices right' in a supposedly efficient market setting, has overlooked the significance of capabilities and institutions. It has also underemphasized the positive role of policy instruments, especially selective ones, in providing correct incentives and generating the technological capacity to respond to those incentives. While policy interventions are necessary for sustained industrial development, not all are efficient or desirable. Development experience is replete with cases of uneconomic interventions. The secret of success in achieving technological dynamism has been in combining incentives with adequate capabilities and institutions, each supported by a proper mix of selective and functional policy interventions.

(ix) A supportive international economic and policy environment for promoting technology transfer and technological dynamism in developing countries would be based on a number of elements. First, in order to revitalize investment in new technology from foreign and domestic sources, decisive steps by the international community to ease the adverse effects of financial and balance-of-payments constraints of economically stricken countries can no longer be postponed, especially in developing America and Africa. Secondly, the resolution of outstanding international trade policy issues -- particularly in areas such as intellectual property, services and investment measures -- should be accomplished in a way which takes full account of the developmental, trade and technological objectives of developing countries. Thirdly, drawing lessons from the experience of successful East Asian industrialisers would seem to suggest, *inter alia*, some re-direction of structural adjustment programmes towards strengthening the combination of capabilities, market incentives and institutions conducive to technologial dynamism. Finally, there is a need to further explore initiatives for stimulating technological cooperation, such as:

(i) A new look at mechanisms in developed countries for encouraging technology transfer to developing countries, such as tax incentives (e.g. greater possibilities for offsetting losses on investments in developing countries against home-country tax liabilities);

(ii) Possible measures for encouraging non-commercial forms of enterprise-to-enterprise co-operation in training of engineers, technicians and R and D personnel, either on the job or on an exchange basis; and,

(iii) Renewed consideration for strengthening of technological linkages among developing countries and their enterprises in light of the kinds of schemes under way among EEC countries.

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INTRODUCTION

1. This report responds to the concerns and requests expressed by the Committee on Transfer of Technology at its seventh session and, in particular, to paragraph 2 of Committee resolution 32 (VII). It also addresses issues raised by the Trade and Development Board in its resolution 380 (XXXVI).

2. In an increasingly interdependent global economy, the prospects for technological progress are determined not only by domestic, but also increasingly by external forces, a tendency that is especially pronounced for many developing countries. Chapter I of this report concentrates on the latter set of influences on the transfer and development of technology in developing countries. After a review of recent trends in the flow of technology to developing countries and the influence of financial constraints on such flows, it considers the technological implications of a selected number of the most important developments and issues confronting developing countries in the years ahead, including the emergence of new technologies, new directions in intellectual property rights protection and inter-firm technological linkages, the role of technology in sustainable development and some aspects of the evolution of international trade relations.

3. In the final analysis, it is how these and other factors influence the productive decisions of industrial enterprises that will ultimately determine the pace of technological change in developing countries. By providing the domestic policy framework in which their firms operate, developing country Governments also have it within their power to shape technological progress during this decade. Chapter II is an interpretation of lessons to be drawn from the recent experience of some developing countries in building up the technological dynamism of their industries. Although it presents quantitative indicators from a wide range of developing countries, the bulk of discussion is confined to a small number of the more successful East Asian developing countries, about which information is available in the existing development literature. Chapter III, which draws together the main conclusions of the report, provides a basis for discussion of possible options for international co-operation to promote the transfer of technology and improve the technological development prospects of developing countries in the present decade.

Chapter I

GLOBAL ENVIRONMENT FOR THE TRANSFER AND DEVELOPMENT OF TECHNOLOGY

A. Trends in technology flows

1. Dimensions and direction

4. In contrast to its rapid expansion in the 1960s and 1970s, the international flow of technology levelled off or even declined during the first half of the 1980s. This was due in part to declines in developing Africa and America and could be linked to the unstable and stagnating macroeconomic environment, largely generated by the decline in capital flows, increased financial outflows to meet debt obligations and diminished revenues from commodity exports.[1] The period between 1985 and 1988 brought changes in the growth, direction and composition of international technology flows. Amongst the outstanding features was the rapid expansion of technology flows among developed market-economy countries, the reinforced disparity among developing countries as host countries and the continued low level of Eastern European and intra-developing country technology flows (see table 1). Technology-related flows to and from developed market-economy countries grew much faster than merchandise trade,[2] thus pointing to the growing importance of the transfer of technology in shaping the global network of economic relationships. The sustained expansion of developed market-economy countries and the corresponding import boom, particularly in the European Community and Japan, boosted capital goods trade, foreign direct investment and technology payments.

5. While technology flows to developing countries in this period increased in nominal terms, they grew very little in real terms. The participation of developing countries in developed market-economy countries' capital goods exports and foreign direct investment outflows continued to decline. Developing countries accounted for only 18 per cent of developed market-economy countries' capital goods exports and for 19 per cent of their foreign investment flows, compared with 32 per cent and 26 per cent respectively in 1980. Despite the very slow growth of technology flows to developing countries as a whole, there was a rapid increase in all major types of technology flows to developing Asia, and especially to those countries belonging to the group of major exporters of manufactures[3] (see table 2). The share of Asia in developed market-economy country exports of capital goods to developing countries continued to climb, reaching 60 per cent in 1988. Flows of foreign direct investment to developing Asia surged even more rapidly between 1985 and 1988, by which time this region had overtaken developing America as the major recipient of foreign direct investment among developing countries.

6. The flow of capital goods to developing America increased in nominal terms from 1985 to 1988 but remained unchanged in real terms. The nominal increase in 1987 and 1988 can largely be attributed to FDI flows of $5.2 billion and $3.2 billion to Bermuda and Cayman Islands respectively. Of the rest, Mexico alone absorbed 50 per cent of the total remaining flows to Latin America. In Africa, imports of capital goods fell in real terms over the period. The surge in foreign investment in 1987/1988 was due to Egypt and Nigeria, which together took in 85 per cent of the total inflow for the region. The remaining countries in the region continued to play a marginal or even diminishing role as host countries compared to the rest of the developing world, a statement that would apply equally well to least-developed countries from all regions. A notable

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1 For a review of the behaviour of technology flows from 1960 to 1985 and their economic impact during the first half of the 1980s, see UNCTAD, "Recent trends in international technology flows and their implications for development" (TD/B/C.6/145), 18 August 1988. For a discussion of the limitations in the measurement and interpretation of the transfer of technology, see UNCTAD, "Technology indicators and developing countries" - study by the UNCTAD secretariat (UNCTAD/ITP/TEC/19), forthcoming, 1991.

2 This is shown by all the indicators of international technology flows. See table 1. Annual growth rates of merchandise exports between 1980 and 1988 were 4.2 per cent (world) and 6.0 per cent (developed market-economy countries). Corresponding figures indicating technology flows for 1985/1986 to 1987/1988 were 13.7 per cent (world) and 16.2 per cent (developed market-economy countries). See UNCTAD, *Handbook of International Trade and Development Statistics*, 1989, table 1.5.

3 Major exporters of manufactures include Brazil, Hong Kong, Mexico, Republic of Korea, Singapore, Taiwan Province of China, and Yugoslavia.

Table 1

Indicators of international technology flows (1980-1988)

(Billions of dollars, current prices)

Indicator	1980	1981	1982	1983	1984	1985	1986	1987	1988	Growth 1980/81 to 1987/88	Growth 1984/85 to 1987/88
A. Capital goods exports [a]											
1. DMECs to world	356.4	365.7	350.6	340.3	367.6	389.2	469.1	557.4	628.7	7.3	25.2
2. DMECs to DMECs	216.1	213.7	206.1	212.0	241.0	261.4	326.3	399.5	452.9	10.2	30.2
3. DMECs to DCs	114.3	127.9	120.6	104.4	102.8	97.8	107.7	126.2	143.5	1.5	16.0
4. DMECs to Eastern Europe	11.1	9.5	9.9	10.5	8.6	9.0	11.8	11.7	13.3	2.8	19.2
5. Eastern Europe to DCs	6.9	7.1	7.5	7.2	8.7	6.6	..	..	..	..	..
6. DCs to DMECs	13.6	15.6	17.0	21.3	28.1	28.4	33.9	44.7	56.3	21.7	49.2
7. DCs to DCs	12.0	14.0	13.2	12.7	13.3	12.9	11.2	12.4	..	-1.6	..
B. Foreign direct investment flows											
8. World to DMECs	41.3	42.6	30.0	33.5	38.6	35.7	63.6	94.5	118.8	14.2	69.4
9. World to DCs	10.8	14.9	13.9	9.8	10.9	11.7	12.1	21.4	22.3	7.9	39.2
10. DCs to world	1.1	0.2	1.1	0.8	0.4	0.6	0.8	1.7	5.0	26.4	160.8
C. Technology payments											
11. World to DMECs	16.7	20.7	21.2	23.6	24.2	24.9	38.0	42.6	47.8	28.0	35.6
12. DCs to DMECs [b]	2.2	2.4	2.2	2.5	2.4	1.4	..	..	..	..	..
D. Technical co-operation grants											
13. DMECs to DCs	7.3	7.4	7.4	7.7	7.7	8.2	9.6	11.6	12.6	7.4	23.0

Source: UNCTAD secretariat computations based on data from: (i) United Nations, for capital goods exports; (ii) UNCTC, for foreign direct investment flows; (iii) OECD STIID Data Bank for technology payments from world to DMECs, national sources from OECD countries for royalties and fees (indicator 12); and (iv) OECD for technical co-operation grants.

a Includes SITC/Rev. 1, Section 7, Machinery and Transport equipment *except* 7194 domestic appliances, non-electrical; 7241 television receivers; 7242 radio broadcast receivers; 7250 domestic electric equipment; 7321 passenger motor cars; 7326 chassis for passenger motor cars; 7329 motor cycles; and 7331 bicycles.

b Flows into France, Federal Republic of Germany, Japan, Italy and United States only.

Memo item:	1980	1981	1982	1983	1984	1985	1986	1987	1988
Export unit values of manufactures exported by DMECs (1980 = 100)	100	95	92	89	86	87	103	112	124

(..) = not available, and (-) = nil or negligible.

Table 2

Technology-related flows to and from developing countries and territories

(Billions of dollars)

Indicator	All developing countries [a]		By geographical region						By analytical group				China [c]	
			Developing America		Developing Africa		Developing Asia		Major exporters of manufactures [b]		Least developed countries [b]			
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
I. Capital goods [d]														
1980	114	14	32	4	25	-	54	9	24	8	4	-	4	-
1981	128	16	36	4	27	1	62	10	24	9	3	-	3	-
1982	121	17	29	5	23	-	66	12	21	10	3	-	2	-
1983	104	21	21	5	19	-	63	15	20	13	3	-	3	-
1984	103	28	24	7	18	-	58	20	23	17	3	-	4	-
1985	98	28	26	8	17	-	53	20	23	18	3	-	10	-
1986	108	34	29	9	17	1	58	24	29	22	3	-	11	-
1987	126	45	32	10	16	1	74	32	46	30	4	-	9	1
1988	144	56	36	13	17	1	87	41	56	39	4	-	9	1
II. Foreign direct investment														
1980	10.8	1.1	7.1	0.4	0.3	0.1	3.2	0.6	4.4	0.4	0.3	-	-	0
1981	14.9	0.2	7.6	0.2	1.5	0.1	5.6	0.1	6.3	0.2	0.3	-	0.3	0
1982	13.9	1.1	7.4	0.4	1.4	0.1	4.9	0.6	5.5	0.8	0.2	-	0.4	-
1983	9.8	0.8	4.0	0.3	1.2	0.1	4.4	0.4	3.6	0.4	-	-	0.6	0.1
1984	10.9	0.4	4.7	0.1	1.4	0.1	4.7	0.3	4.0	0.2	0.1	-	1.3	0.1
1985	11.7	0.6	5.6	0.1	2.6	-	3.4	0.4	3.5	0.4	0.1	-	1.7	0.6
1986	12.1	0.8	6.1	0.2	1.8	-	4.2	0.6	2.8	0.5	-	-	1.9	0.4
1987	21.4	1.7	10.8	0.2	2.2	0.1	8.2	1.4	6.5	1.3	0.2	-	2.3	0.6
1988	22.3	5.0	9.3	0.1	2.8	-	9.9	4.8	7.0	4.5	0.2	-	3.2	0.8
III. Technical co-operation grants [e]														
1980	7.3		1.2		3.1		1.8		0.2		1.5		0.1	
1981	7.4		1.2		3.0		1.8		0.2		1.6		0.1	
1982	7.4		1.0		3.0		1.9		0.2		1.6		0.1	
1983	7.7		1.0		3.2		1.8		0.2		1.6		0.1	
1984	7.7		1.0		3.2		1.7		0.2		1.6		0.1	
1985	8.2		1.2		3.5		1.8		0.2		1.8		0.1	
1986	9.6		1.5		4.1		2.1		0.3		2.1		0.2	
1987	11.5		1.8		4.7		2.5		0.3		2.4		0.3	
1988	12.6		2.0		4.9		2.9		0.4		2.6		0.3	

Source: UNCTAD secretariat computations based on data from: (i) United Nations, for capital goods imports; (ii) UNCTC, for foreign direct investment; and (iii) OECD, for technical co-operation grants.

a Total also includes developing countries and territories of Europe and Oceania, and is subject to rounding.

b Major exporters of manufactures: Brazil, Hong Kong, Mexico, Republic of Korea, Singapore, Taiwan Province of China and Yugoslavia. Least developed countries: See UNCTAD, *Handbook of international trade and development statistics, 1989*, United Nations Sales No. E/F.90.II.D.1, September 1990.

c Memo item.

d See *footnote a* in table 1 for definition.

e Grants that the donors have not allocated to individual countries are not included in the regional or analytical groups, but are included in the total for developing countries.

feature of this latter part of the decade was the growing reliance of African and least-developed countries on technical co-operation grants as a source of imported technology.

7. Special attention must be drawn to the substantial expansion of China's capital goods imports in the latter part of the decade as compared with the first half. Foreign investment also grew during these years, reaching a level in 1988 ten times that of 1980.

8. Developing countries continued to increase their importance as exporters of capital goods and as foreign investors in developed market-economy countries during the second half of the decade, as shown in table 2. Though still small in absolute terms, the growth of these outflows from developing countries (primarily the major exporters of manufactures) outpaced the corresponding outflows from developed market-economy countries. Part of these flows was directed towards other developing countries to take advantage of lower wage costs and other locational advantages, as well as growing regional markets (in Asia). The most rapidly growing part of these flows, however, has been directed to developed market-economy countries, where it has been attracted by markets and by the accessibility of technology.

2. *Financial constraints*

9. In contrast to a minority of rapidly growing exporters of manufactures in Asia, the majority of developing countries remained severely limited in their ability to acquire technology in the second half of the decade. As stated above, constraints imposed by net financial resource outflows and the instability of commodity prices continued to be the major barrier for numerous developing countries. Because of the implications for the 1990s, several aspects of the adverse effect of financial constraints on technology flows deserve closer attention.

10. First, "opening economies to foreign investment", as some have suggested,[4] will not by itself cause foreign investment inflows to grow more rapidly and reduce these constraints. This is because foreign investment is influenced by country credit ratings which are themselves determined by the existing status of a country's balance-of-payments, reflecting *inter alia* the role of other financial flows. The evidence shows that the countries which have received the bulk of foreign direct investment have been the ones which also received other types of financial flows such as commercial lending and official assistance.[5] Moreover, least developed countries, including those in sub-Saharan Africa, that were among the first to enact legislation favourable to foreign investment in the 1970s and earlier, have been singularly unsuccessful in attracting this form of technology transfer.

11. A second and central concern for developing countries is the cumulative effect of external financial constraints in influencing their productive capacity and their ability to keep pace with global technological changes. This concern gains particular importance as it has proven difficult to replace imported capital goods with domestic ones.[6] The majority of developing countries produce only a limited range of capital goods which are required to sustain investment in plant and machinery, focusing mainly on the low-technology-intensive metal products industry. Moreover, the high degree of specialization in the capital goods sector makes it virtually impossible even for advanced countries to rely exclusively on domestically produced capital goods.[7]

12. The quantitative evolution of the productive capacity (see figure 1) can be observed by an estimation of the net stock of invested capital. Although the assumptions needed to estimate this figure are imperfect, the marked differences across the geographical regions[8] highlight the long-term implications of capital accumulation. The recent declines in capital stocks for developing America and Africa are underestimates because they do not take full account of the decline of asset values due to technological change. In this context, a decline of capital stock does not simply re-

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4 See "Mosbacher presses LDCs to open up to investment", *U.S. Daily Bulletin*, 1 June 1989, Geneva.

5 Source - unpublished UNCTAD research work based on cross-country and time-series analysis of over 50 developing countries.

6 For a discussion on factors that impede substitutability and empirical evidence for limited possibilities of substitution, see J. Hentschel, "Availability of intermediate and capital goods in import-restrained debtor countries", UNCTAD discussion paper No. 29 (April 1990).

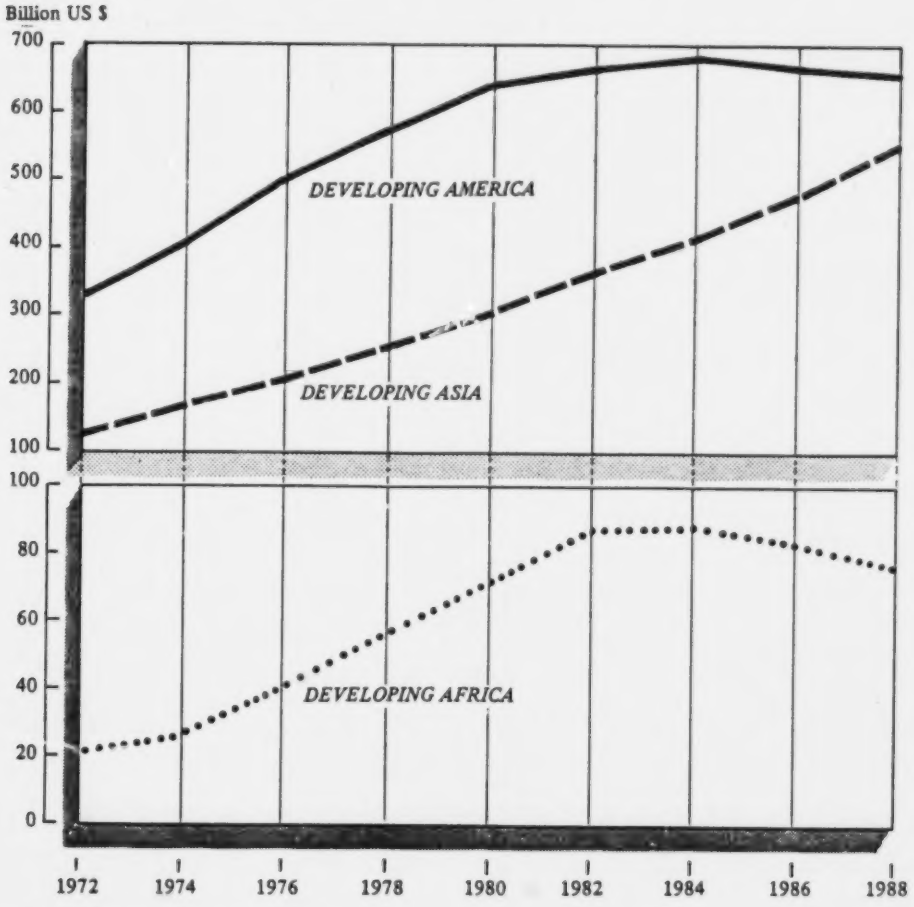
7 It has been suggested that the economically efficient limit to import substitution in the capital goods sector has probably been adjusted downward due to the economies of specialization. See C. Edquist and S. Jacobsson, *Flexible automation - The Global Diffusion of new Technology in the Engineering Industry* (Oxford, Basil Blackwell, 1988).

8 Among the selected countries there are a few exceptions which do not conform with the geographical development paths (see chapter II).

Figure 1

Total net capital stock [a] of 29 selected developing countries and territories [b] by geographical region (1980)

(Billions of United States dollars)



Source: UNCTAD secretariat computations based on data from UNSO and UNIDO.

a The net stock of capital was calculated on the basis of imported capital goods and domestic capital goods output. See note in table 1 for a definition of imported capital goods (SITC 7 minus transport equipment and consumer durables). The domestically originated contribution to the capital stock was calculated by taking the output of industries (ISIC 381 to ISIC 385 minus exports). IMF exchange rates were applied to convert national currencies into US dollars and UNCTAD country-specific deflators for SITC 7 to arrive at real values. A straight-line method of depreciation was applied to calculate net stocks, based on the assumption of a useful economic life of 11 years. Since data for both trade statistics and industrial production were available for 1962 and onwards, an initial capital stock could be estimated for 1972.

b For a list of the 29 selected developing countries and territories, see table 3 or 4. These countries and territories represent 67 per cent of the total GDP (1987) and 72 per cent of the total population (1987) of the developing countries. The geographical representativeness in terms of population is 86 per cent for developing America, 40 per cent for developing Africa and 81 per cent for developing Asia.

flect a reduction of productive capacity,[9] it also implies that the ability to keep up with global technological advances has diminished. Since these advances have been taking place so rapidly, the shrinkage in capital stock will make it even harder for some countries to maintain or achieve international competitiveness in the 1990s.[10] This point is taken up further in section 1 of part B.

B. Selected global developments

13. The past two decades have brought significant changes in the environment for the transfer of technology. Major advances have occurred in biotechnology, materials technology, microelectronics and other disciplines. The number of countries whose firms are able to generate new technologies has grown, as has the number of countries whose firms are able to use and compete internationally with innovations developed elsewhere. An increasingly competitive global technological climate has induced changes in policies on the part of both firms and Governments -- a development that is likely to affect the transfer of technology to developing countries during this decade. The increased international focus on the impact of technology on the environment, growing out of the renewal of concern about the sustainability of development, has implications for both developed and developing countries. Also likely to affect developing countries is the inclusion of technology-related trade issues in negotiations that have taken place in various fora, the creation of economic groupings and the transformation of Eastern Europe. The remainder of this chapter takes up the issues that are raised for developing countries by these developments.

1. Emergence of new technologies

14. Of all the major recent technological advances, those that appear to be the most far-reaching are in biotechnology, materials and microelectronics. Modern biotechnology has a large potential that is already being realized in pharmaceutical and medical applications and is just beginning to be exploited in agriculture.[11] The development of this industry in developed market-economy countries is said to be connected with judicial decisions that have granted intellectual property rights to innovators over genetically engineered 'forms of life'. The enormous costs of biotechnological R and D are leading to a growing concentration of activities in this field in the hands of large pharmaceutical and chemical companies. What these two developments mean in terms of the generation and diffusion of innovations in this field and of their transfer to developing countries is still not well understood. The need to amortize their investments in research has meant that biotechnological companies have been concentrating their efforts on applications tailored for the largest and most lucrative markets, primarily in developed market-economy countries. Although genetic engineering is beyond their reach, a fair number of developing countries may be in a position to obtain spin-offs from the above applications adapted to their own needs through the utilization of biotechnologies at the less sophisticated end of the spectrum, for example tissue culture and cloning. Access during the 1990s will depend on the domestic availability of skilled scientific and technical personnel and on the ability to link up with external suppliers for the basic technology.

15. With respect to *materials technologies*, previous UNCTAD reports have underscored their adverse impact on consumption in development market-economy countries of raw materials of export interest to developing countries.[12] There is little reason to believe that technological and other factors shaping the intensity of use of raw materials will diminish their force during the

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9 On the basis of the selected countries, developing African countries as a group experienced a shrinking in their productive capacity of over 15 per cent during the 1980s and developing America of about 10 per cent, while developing Asia increased total capital stocks by around 80 per cent.

10 For empirical evidence in the textile and metal products industry and an analysis of the evolution of the productive capacity and the nature of export performance, see G. Kell and S. Marchese, "Developing countries' exports of textiles and metals: The question of the sustainability of recent growth", *UNCTAD Review*, forthcoming.

11 See "Agricultural biotechnology: preliminary assessment of potential impact on developing countries' trade", note by the UNCTAD secretariat (TD/B/C.6/154), for a more detailed discussion of these and related issues for agriculture.

12 See "Impact of new and emerging technologies on trade and development: a review of the UNCTAD secretariat's research findings", report by the UNCTAD secretariat (TD/B/C.6/136) and "Impact of technological change on patterns of international trade", report by the UNCTAD secretariat (UNCTAD/ITP/TEC/3).

present decade.[13] Although economic growth, particularly in developing and Eastern European countries, could be sufficient to offset these trends and permit a modest expansion in materials demand, such expansion is highly unlikely to match the pace achieved during the 1950s and 1960s. Consequently, technology flows into mines and materials-based manufacturing will also be modest during this decade.

16. Modern industry in the developed market-economy countries has been undergoing a fundamental structural, technological and organizational transformation. Its key features are growing product diversity, and quantum leaps in productivity and increasing flexibility, stemming from the development and diffusion of a family of automation technologies, including flexible manufacturing techniques and new products deriving from microelectronics-based control and communications systems. Some have argued that the spread of these technologies may cause developing countries to lose their attractiveness as low-labour-cost locations for production. Computer-aided design and manufacturing are increasing the knowledge content and reducing the labour content of industries producing such goods as wearing apparel, consumer electronics and automobiles. Secondly, just-in-time delivery systems are said to be working against the location of components and parts manufacturing on sites distant from assembly operations in the developed country markets. Thirdly, flexible manufacturing systems within firms and a range of inter-firm links in design and production are said to be reducing the importance of low-cost labour. The reason is the greater relative importance attributed to non-price marketing considerations associated with emphasis on quality and shifts in demand. The impact of these tendencies ought to be an erosion of the global comparative advantage of developing countries, leading to a shift of production location to the north. Thus far, however, trade figures do not reveal an adverse impact. From a share of about 5 per cent of world exports of manufactures in 1970, developing countries accounted for 9 per cent in 1980 and 15 per cent in 1987.[14] The behaviour of the transfer of technology also fails to reveal evidence of a shift in the location of production. Investment and technology flows to developing countries as a whole were stagnant or declining (as shown in the earlier part of this chapter) during the 1980s, but this was due primarily to the precarious economic situation in most Latin American and African countries. Developing country exporters of manufactures, whose comparative advantage ought to have been the most directly affected by the technological changes, have been continuing to attract a record volume of foreign investment and other technology inflows from developed market-economy countries. There must therefore be offsetting positive factors that explain the continued competitiveness of developing country exports. No systematic empirical studies have been made to explore this issue. Attempts to interpret the impact of new technologies on trade patterns therefore remain speculative. One set of explanations focusing on technological development in the North is that: (i) computer technologies have not been applied to all branches of manufacturing and there exists an important range of activities (for example stitching and assembling of garments in the clothing industry) that still depend on labour-intensive production methods; (ii) new technologies have not been adopted as rapidly as anticipated because the cost and other advantages of using them are still not sufficient to outweigh existing techniques, given prevailing wage scales; and (iii) where they have been adopted, the period required for the adjustment of personnel to the new techniques has been longer than anticipated. Another line of reasoning is that companies in developing countries have themselves taken advantage of the new equipment, thereby retaining their cost advantage, albeit at a lower level. In support of this interpretation is the dramatic surge of capital goods imports of Asian developing countries during the 1980s (table 2), a substantial part of which consists of equipment embodying the new technologies. Scattered evidence from a number of sources, including the UNCTAD secretariat's background research on the international diffusion of textile machinery and its most recent report on the capital goods sector, provide indications that investment in computer-driven equipment by exporters of manufactures in these countries may be one of the reasons that they have been able to continue increasing their shares in international markets throughout the decade.[15]

17. For the 1990s then, the available evidence suggests that the overall impact of computer technologies on competitiveness and technology transfer in the developing countries need not be adverse. There is a strong possibility, though, that the more technologically advanced developing

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[13] John E. Tilton, "The new view of minerals and economic growth", *The Economic Record*, vol. 65, No. 190 (September 1989).

[14] Secretariat estimates based on data of the United Nations Statistical Office.

[15] See "The diffusion of electronics technologies in the capital goods sector in some developing countries" - study prepared by Charles Edquist and Staffan Jacobsson in co-operation with the UNCTAD secretariat (UNCTAD/ITP/TEC/10); "Special report -- computers at work", *Asian Business*, November 1987, pp. 74-76.; A.Y.C. Nee and S.L. Long, "Microcomputer-aided material management in a furniture factory", *Computers in Industry*, vol. 10, No.4 (1988); K.H. Poh, "NC applications -- its present and future in Singapore's industries", *International Journal of Operations and Production Management*, vol. 4, No. 1 (1984).

countries will pull ahead of other developing countries whose education and skill levels are not adequate for the transformation. For some countries, this disadvantage would add to the other constraints that they already face in attracting foreign and domestic investment in new plant and equipment (see section A of this chapter).

18. A wholly different type of issue is raised by the impact of the new technologies in developed countries themselves. The slow structural adjustment of many of these countries suggests that the diffusion of technological innovations in their industries is not taking place fast enough. Costly protectionist policies have delayed the movement of resources in those countries out of declining industries in which comparative advantage has shifted to developing countries and into promising areas where the new technologies have the greatest potential impact.[16]

2. *New directions in intellectual property rights protection and inter-firm technological linkages*

19. During the 1980s, the importance of protection of firms' technological assets became more keenly felt as the number of technologically proficient firms increased globally and as competitors became better able to assimilate and reproduce technology. As they have in the past, companies relied on a variety of means to protect their technology from imitation by competitors, including intellectual property rights protection (patents, copyrights and trademarks), proprietary secrecy, lead time in introducing new products, learning curve advantages and access to complementary assets without which the technology cannot be exploited. While relying on all of these approaches, United States firms which felt most threatened by increasing global competition led the way in pressing for greater enforcement of intellectual property rights protection during the 1980s -- a trend that has been followed in the EEC, Japan and other industrialized countries. Damages awarded to petitioners have risen, the scope of application of intellectual property rights has been widened and in the United States it has become easier since 1988 to bar imports of goods alleged to be infringing. The threat of trade retaliation and other inducements brought forth in bilateral negotiations has led a considerable number of developing countries to strengthen standards of intellectual property protection. Indicative of the change in climate for those industries that depend on patents is the pattern of judgements on patent infringement cases in United States courts. Whereas two-thirds of such judgements had gone against the patent holder in the 1970s, the rulings in the 1980s were running 70 per cent in favour of the patent holder.[17] Moreover, the courts in many developed market-economy countries have increasingly applied doctrines which exempt restrictive practices in licensing agreements from the application of competition laws, where such practices result from market-dominating positions of firms conferred by intellectual property rights.

20. Paralleling the trend towards strengthening of intellectual property rights protection have been the mergers, joint ventures and various types of strategic technological alliances that have characterized the behaviour of many firms manufacturing high-technology products in the developed market-economy countries. Two related factors responsible for this behaviour have been the growing cost of R and D and the desire to protect innovations from imitation. Mounting R and D expenditures needed to bring out new products and processes have induced companies to establish such formal and informal collaborative links with other companies -- often in the same industry -- in order to spread the large risk involved and permit the realization of economies of scale in research. The partners in such ventures are also able to benefit from specialization and cross-fertilization while diminishing the cost of duplicative research efforts. The second and perhaps more important driving force behind inter-firm research and innovation linkages in the developed market-economy countries stems from the desire of firms to protect their innovations from imitation. Despite the campaign to strengthen intellectual property rights protection, empirical investigations have shown that in practice intellectual property rights alone do not offer adequate protection from imitation by competitors, and managerial personnel themselves have given relatively little weight to the importance of patents and copyright alone in protecting against imitators. This is in line with the stagnation in the number of internationally registered and approved patents

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[16] See "Structural adjustment issues in the world economy" - report by the UNCTAD secretariat (UNCTAD/ITP/25), 9 March 1990.

[17] See J. Kerr, "Management's new cry: fight for your technology rights", *Electronic Business* (15 August 1988); and G.M. Hoffman in J.Osepchuk (ed.) "A written panel discussion on patent issues", *IEEE Technology and Society* (September 1988).

in recent years[18] and the relatively slower growth of technology licensing compared with other technology transfer activities.[19] Experience has shown, particularly in the case of United Kingdom and United States companies, that the ability to generate innovations is not sufficient to guarantee the capture of the greatest share of returns from their exploitation, and that complementary assets such as well-developed manufacturing, marketing, after-sales service or other capabilities are often more critical. Competitors better endowed with such assets may have an edge in getting the most profit from the originating firm's innovation. Thus, an important rationale for the observed tendency towards co-operative innovation is the perceived need to bring together R and D capabilities with other types of assets that are missing in order to protect returns from new technology and maximize the gain from its explotation. Similar complementarities are at the heart of growing collaboration by enterprises with government agencies, universities and research institutes.

21. As in other areas of technological endeavour, government policies have played a role in promoting co-operative innovation -- notably the National Co-operative Research Act of 1984 which gave preferential antitrust treatment to such ventures in the United States and Regulation 418/85 under Article 85, Section 3 of the EEC Treaty which gives a so-called 'block exemption' from anti-monopoly regulations for both the conduct of R and D and the joint exploitation of the results.[20]

22. One fear that has been expressed is that the developments described in this section will raise the cost and hinder the access of developing countries to imported technology in the coming years. Tighter intellectual property rights protection and growing secrecy would be expected to permit technology suppliers to seek higher economic rents on their innovations. Interviews carried out on behalf of the UNCTAD secretariat do suggest that royalty rates on patents, know-how and other forms of intellectual property may be on the rise. Thus, developing countries can be expected to experience higher licencing payments in patent-intensive industries during the 1990s. Secondly, the easing of competition rules for innovative collaboration among firms does reduce constraints against cartels and monopolistic practices. Even if such collaboration did not lead to an increase in anticompetitive practices, it is to be expected that there will be an increasing tendency to transfer technology within the collaborative group than with the outside. Since developing countries lack the research capabilities and other assets to be a part of this collaboration, their access to technology could be adversely affected as such arrangements grow in importance.

23. These negative effects might, however, be offset by other factors. First, patenting, copyrights and secrecy are of major importance only in parts of the manufacturing sector -- mainly in segments of the pharmaceuticals, chemicals, semi-conductor and computer industries. In most other industries, commercialized technology may be obtained from a variety of sources and in different forms, for example through machinery sales, including turn-key plants, joint ventures, technology sales, technical services, management contracts and other forms. Moreover, technology is available from a greater number of countries than in the past, including some of the more advanced developing countries. Secondly, despite the tightened enforcement referred to above, surveys show that intellectual property law has a limited ability to provide protection from imitation and that even R and D collaboration may be insufficient, unless many potential competitors are in the same joint venture.[21] Thirdly, although the accessibility of high technology is and will continue to be more restricted than for more mature technology, the incentive to transfer it has been strengthened, particularly for smaller firms, by the steep rise in R and D costs and the shorter commercial lives of new innovations. In addition, it has been noted that the world market price of computers, robots and other applications of information technology that are the basic building blocks of modern manufacturing has been declining historically, a trend that may well continue during the present decade in parallel with the falling price of semiconductors.[22]

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18 Data on patents of foreign origin supplied by the United States Patent Office.

19 Graham Vickery, "A survey of international technology licensing", *STI Review*, OECD, Paris, No. 4 (December 1988).

20 Referred to in Carl Shapiro and Robert Willig, "On the antitrust treatment of production joint ventures", *Journal of Economic Perspectives*, vol. 4, No. 3 (Summer 1990).

21 Thomas Jorde and David Teece, "Innovation and cooperation: implications for competition and antitrust", *Journal of Economic Perspectives*, vol. 4, No. 3, (Summer 1990). Moreover, one expert has found that "for both processes and products, the odds are better than 50-50 that a development decision will leak out in less than 18 months ... this means [an] innovation project is half completed": Edwin Mansfield, "How rapidly does new industrial technology leak out?", *Journal of Industrial Economics* (December 1985).

22 The price of a semiconductor (dynamic random access memory or DRAM) per digitalized unit of stored information (or bit) is one thousandth of its price 15 years ago. The rising R and D cost of successive generations of semiconductors has been largely outweighed by the increase in the number of bits of information that can be stored in a single semiconductor, which has doubled roughly every 18 months. See Marc Humbert, "Global study on world electronics", UNIDO (ID/WG.478/2(SPEC.)), 5 September 1988.

3. Technology and sustainable development

24. A major challenge for the world community in the 1990s and beyond is how to elaborate and implement a strategy for sustainable development. Although they are the least to blame for the deterioration of the global environment, developing countries have an important stake in the successful outcome of such a strategy because of the fragility of their ecosystems and the limited means at their disposal for coping with environmental problems. The transfer and development of technology is an essential component of a successful strategy of sustainable development. The application of environmentally sound technologies -- whether imported or developed locally -- can contribute significantly to raising the productivity and sustainability of resources in such areas as agricultural production, renewable energy generation and pollution control. A large part of the challenge will be to assure the widest possible diffusion of the technologies, overcoming such obstacles as lack of knowledge and ability to pay for them. In this connection, proprietary rights associated with the commercial development of many environmentally sound technologies could be an impediment to their rapid diffusion, particularly in developing countries.[23]

25. The transfer and application of technologies compatible with sustainable development poses many of the same problems as technologies more generally, plus some additional ones. Ability of users to pay for them does not necessarily imply that they are aware of them or that they will be capable of adapting them to their particular circumstances. Nor does it imply a prior knowledge of how a particular productive activity will affect the environment and a spontaneous willingness by individual producers to take the necessary steps in order to avoid adverse environmental effects. Moreover, many of the needs of developing countries, associated with particular geographical and socio-economic conditions (such as dryland farming and small-scale producers), cannot be met by existing commercial suppliers of technology and are not a part of their R and D programmes. Because of their accumulated production experience and pool of technical, scientific and managerial skills, the more industrialized countries are better placed to confront these challenges. In general, the technological development that accompanies industrialization increases the capacity to cope with environmental risks, the awareness of technological alternatives and the knowledge base upon which environmentally sound production decisions are made. But technological development requires a conscious effort by both enterprises and Governments -- an issue that is taken up in chapters II and III.

4. Evolution in international trade relations

26. Changes now under way in the pattern of international trade relations are of considerable relevance to the future prospects for the transfer of technology and technological development in developing countries. The two major developments which stand out most prominently are the adoption of a strengthened international trade regime and the enlargement of the European space.

(a) Strengthening the international trade régime

27. Explicitly or implicitly, technology issues form an integral part of international trade relations. Trade expansion contributes to technological development by permitting countries to exploit economies of scale and specialization leading to lower costs and improved productive efficiency. For individual countries, exports help to generate foreign exchange reserves and domestic savings, thereby increasing the supply of resources available for investment in capital formation embodying the latest technological advances. Acquisition of knowledge through technology transfer permits a country to complement its own efforts by taking advantage of the accumulated experience of others. Technological dynamism and particiation in the international trading system reinforce one another reciprocally. On the one hand, attainment of a certain level of technological capability helps a country's enterprises meet the price and quality standards required in order to penetrate international markets; on the other hand, the very struggle to become more internationally competitive stimulates the efficient accumulation of skills and drives its enterprises to seek and adopt new innovations.

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[23] Mindful of the need for international co-operation in order to tackle these and related problems, the General Assembly, in its resolution 44/228 of 22 December 1989, decided *inter alia* that the United Nations Conference on Environment and Development, being held in 1992, should have as one of its objectives the examination and recommendation of modalities for favourable access to, and transfer of, environmentally sound technologies, in particular to developing countries, including on concessional and preferential terms.

28. The reason that this interaction between trade and technology is so important is that technological change is the driving force behind economic development, and in countries that do not produce technology, trade is one means of obtaining it. It is in this context that developing countries seek more liberal and secure conditions of access for their exports into the markets of developed countries. It also explains their concern over any move that could bring into question the principle of differential and more favourable treatment for developing countries. Apart from the overriding question of market access, several issues being discussed have a particular bearing on technology transfer and technological development prospects of developing countries.

29. Most directly relevant to technology is the campaign aimed at the establishment of uniform and strengthened international standards of protection of intellectual property rights.[24] The economic rationale for increased protection is the expectation that the growth and productivity-generating effects from encouraging global investment in R and D will more than offset the slower diffusion of the resulting innovation -- a slower diffusion that arises on account of the increased cost of the technology to users. Proponents of the reforms have sought to tilt towards holders of innovations the balance which has heretofore existed between promoting innovations and securing their adequate diffusion. Their call for uniform protection across all countries and technologies tends to discriminate against users of technology in both developed and developing countries. However, a developed country may be able to recoup losses to its technology users in one activity by reaping high returns in other activities in which its firms have a technological edge. Few developing countries are in a comparable position. Hence, they will be net losers as a result of having to pay the higher costs of technology in industries subject to protection, especially since the benefits from technology generation will not accrue until the more distant future when their firms have achieved the capacity to produce patentable innovations. A more flexible approach would allow individual countries to fix the level of protection according to the technological capability of their industries under the principle of national treatment. This would avoid discrimination against net users of technology, most of which are developing countries.

30. Though greater intellectual property protection may be a necessary condition for the transfer of technology, proponents of the more flexible approach have argued that it is not a sufficient condition, emphasizing that, in practice, most patents registered in developing countries have remained unexploited (in the sense that they have not led to the creation of domestic production capacity). Thus, the indiscriminate strengthening of intellectual property protection would be unlikely to promote increased diffusion and transfer of technology to most developing countries during the decade, particularly in view of the macroeconomic constraints discussed earlier in this chapter. Instead, the effect would be to elevate the cost of imported products covered by intellectual property protection.

31. The liberalization of world trade in services can in principle benefit all countries, including developing countries. It has the potential to accelerate the technological development of developing countries in the years ahead by stimulating efficiency in key sectors, improving access to imported technological inputs and providing support to exports. The extent to which this actually happens will be determined by whether the liberalization of services trade through negotiated exchange of concessions adequately takes into account the fundamental asymmetries between developed and developing countries in the existing capabilities of their services sectors, particularly those core sectors such as construction and engineering design services, telecommunications, transport and professional and business services in which the technological dimension is most crucial. Trade liberalization, compelling developing countries to adhere rigidly to principles of national treatment, market access and right of establishment would prevent them from taking measures to build up the technological dynamism of their local services firms. Thus, the recognition that their participation in world services trade is to be provided for through a strengthening of their domestic services sectors and that the negotiated access to their markets under schedules of concessions is to proceed with due respect for national policy objectives and levels of development has been viewed as a positive sign. What this might imply in individual sectors and countries will vary with the level of existing capabilities. As an illustration, qualified application of national treatment in construction and engineering design services could involve measures to prompt foreign companies to make maximum use of locally manufactured equipment and local engineers and technicians and to train local personnel.[25] As suggested by the discussion in chapter II, the con-

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[24] A more complete discussion of these issues is contained in A. Yusuf, "Developing countries and trade related aspects of intellectual property rights", *Uruguay round papers on selected issues* (UNCTAD/ITP/10), United Nations, New York, 1989, and I. Gianatsos, "Technology and trade: the developing country perspective" -- paper presented to the Symposium on Technology and Trade Policy at the 1990 American Association for the Advancement of Science Annual Meeting, New Orleans, February 1990.

[25] See Y. Soubra, "Construction and engineering design services: issues relevant to multilateral negotiations on trade in services", *Trade in services: sectoral issues* (UNCTAD/ITP/26), New York, 1989.

tribution of such measures to technological dynamism and competitiveness will also be influenced by how effectively they are administered.

32. The drive to circumscribe the use of investment measures -- that is, the attachment by Governments of certain conditions to their approval of investments -- raises points similar to those discussed above. One position maintains that disciplines should be established across-the-board, in particular on local content and export requirements, on the grounds that such measures distort international trade. A more extreme version of this position would restrict even those investment measures such as joint venture requirements which have no obvious trade distorting effect on the grounds that they limit the international flow of investment. The alternative view would give scope to developing countries to employ such measures where they deem them necessary in order to ensure the maximum impact of foreign direct investment on development, especially technological development, and to counter any anti-competitive practices that might be engaged in by foreign investors. Failure to accord this flexibility for developing countries would be likely to affect those few of them that have been and will continue to be the most successful in attracting foreign investment.

33. Although possible international accords on the three types of technology-related reforms do not pose a grave risk of seriously limiting access to and raising the cost of technology inflows when such reforms are considered individually (except for intellectual property rights), the picture changes when their combined effect on developing countries is considered. Taken together, the uniform imposition of stricter standards of intellectual property rights enforcement, restriction of performance requirements on investment and (possibly) opening up of developing countries' services sectors before they are on a competitive footing could affect developing countries' technological and economic development prospects by limiting significantly the policy options at their disposal for promoting the development of their industrial and services sectors. In particular, in the case of intellectual property rights and investment performance requirements, the number of bargaining chips in the hands of developing country Governments in negotiating foreign investment and technology licensing agreements would be a lot smaller.

(b) The single EEC market and changes in Eastern Europe

34. The completion of the single EEC market in 1992 will affect the transfer of and investment in technology in developing countries during the decade. It will do so both through the expansion and diversion of trade with developing countries and through the removal of barriers to capital flows and other measures favourable to foreign investment in the EEC. As reported in the *Trade and Development Report, 1990*, the net aggregate trade impact on developing countries from removal of the internal trade barriers in the EEC could be small because of the mutually offsetting effects of trade diversion and trade expansion.[26] In principle, this ought to mean a symmetrically small net effect on foreign investment and other technology flows to developing countries attributable to Europe 1992. However, forecasts appear to give the most weight to influences favouring a diversion from developing countries to the EEC.[27] This is associated with the pull effect of increased investment opportunities, real and perceived, made possible by an expanding EEC-wide market. The larger, integrated market for goods and services would induce traders to shift productive capacity to the EEC to take advantage of economies of scale and other forms of improved efficiency arising from operation within the market. The Centre on Transnational Corporations states that foreign direct investment in developing countries is likely to have already been affected by European integration, even though the EEC's new trade policy has not yet been clearly enunciated.[28] This is because some companies are seeking to position themselves even before the completion of the single market.

35. In the absence of a clearly formulated EEC external trade policy, it is not yet evident how accessible EEC markets will be to third countries, including developing countries. Stringent local

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[26] *UNCTAD, Trade and Development Report, 1990* (United Nations publication, Sales No. E.90.II.D.6) New York, 1990.

[27] See M. Davenport and S. Page, "Regional trading arrangements: the impact of the implementation of the single European market on developing countries" - report prepared for the UNCTAD secretariat, October 1989.

[28] "For instance, Intel, one of the world's leading manufacturers of computer chips, with substantial interests in developing countries, has recently invested $400 million in the European Community, a decision motivated directly by the.... local content policy on integrated circuits. In another example, the head of Sony in Europe, speaking about his company's plan to invest several hundred million dollars in Europe, has said: 'If we followed just the economics of manufacturing, we'd ship the lot from South East Asia.'" United Nations Centre on Transnational Corporations, *Regional economic integration and transnational corporations in the 1990s: Europe 1992, North America, and developing countries*, UNCTC Current Studies No. 15, Series A, United Nations, New York, June 1990.

content requirements, rules of origin, anti-dumping measures and other non-tariff barriers could encourage some companies to invest directly in the EEC rather than in developing countries.

36. The dynamic effects of income growth in the EEC could partly offset these effects by favouring investment and other technology flows to countries exporting commodities, mainly fuels, not produced within the EEC and to countries producing goods such as clothing, steel and other less skill-intensive manufactures out of which the EEC could be expected to shift in the longer run. However, the ACP countries benefiting from preferential treatment for their exports under the existing EEC trade régime could be affected unfavourably by any liberalization that might occur after 1992, especially exporters of some manufactures such as clothing and of certain tropical products, notably bananas, which presently enjoy free access to the EEC market.

37. The closer integration of Eastern Europe into the international economic system stemming from the political and economic reforms unfolding in the region has also given rise to speculation about repercussions for developing countries. An assessment of implications for technology flows to developing countries needs to distinguish between effects stemming from increased competition between developing and Eastern European countries in international markets for technology flows *per se* and increased competition for financial flows.

38. With respect to technology flows as such, the overall magnitude of effects (negative *or* positive) for developing countries as a whole is likely to be modest in the short to medium term. In large part, this derives from the relatively small weight of the Eastern European countries in the world economy. Collectively, they accounted for little more than about 3 per cent of global output up to 1988[29] and an even smaller percentage of machinery trade (see, for example, table 1). Only in the event of very rapid growth of their foreign trade, in the order of 20 per cent or more per year, could a significant parallel impact on aggregate technology flows to developing countries be expected to take place. The greater-than-anticipated difficulties of managing the transition in Eastern Europe make such a performance unlikely in this decade. The growing economic ties of Eastern Europe with the EEC are already encouraging a growing number of developed market-economy firms to commit themselves to joint ventures in Eastern Europe to position themselves to take advantage of domestic market opportunities and of abundant skilled labour. Most of this activitiy would represent a diversion of investment that would otherwise have taken place within the EEC, though some shift of investment at the expense of developing countries cannot be ruled out.

39. The relatively modest role of Eastern European countries as potential competitors for technology imports contrasts with their significant role as potential competitors for international financial resources. This is of some importance because of the influence of financial constraints on present and future inflows of technology to developing countries. It has been suggested that the combination of the awesome cost of transforming the Eastern European economies and the political support for large amounts of official assistance for that purpose means that, in the medium term, official resources could be deviated from developing countries.[30] Moreover, the predicted rise in interest rates brought on by the financial effects of German unification will increase debt servicing payments and raise the cost of borrowing for developing countries. Developing countries which previously received official loans from Eastern European countries will be particularly affected by the changes taking place in the latter. Taken together, these financial developments would tend to have a depressing affect on technology flows to developing countries in the 1990s.

40. The preceding discussion has identified and explored several factors that will affect the technological and related trade and development prospects of developing countries during the remainder of this decade. These factors include the persistent economic stagnation and disorder in much of developing America and Africa, global technological advances, the surge of intercorporate technological alliances and change in regulatory climate affecting technology transfer, renewed international concern about the environment and some recent developments in international trade relations. While the external economic climate has pronounced implications for the transfer and development of technology in the 1990s, chapter II suggests that national policy initiatives will also play a role and may, in part, explain the divergent technological trends amongst developing countries.

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29 S. Griffith-Jones, "Changes in Eastern Europe: their potential implications for developing countries and for research relevant to LDC policy-makers", report prepared for IDRC Canada. Institute of Development Studies, University of Sussex, Brighton, September 1990.

30 *Ibid.*

Chapter II

TECHNOLOGICAL DYNAMISM: CONTRASTING NATIONAL EXPERIENCES AMONG DEVELOPING COUNTRIES

A. Introduction

41. There is considerable variation in the efficiency with which industrialization has been carried out by different developing countries. Many factors have contributed to this variable record. Countries started (around the 1950s) from very different points on the industrial scale, some with well established manufacturing bases, others with rudimentary manufacturing facilities (and little of the skills, institutions and infrastructure that go with industry). They were exposed to very different external economic environments and managed their macroeconomic policies with differing degrees of success. Political and natural events were conducive to some countries' development efforts and not to others.

42. Industrial success depends not only on the ability to buy the capital goods and know-how needed, but also on the ability to absorb and efficiently deploy the new technologies, adapt them to local conditions, improve upon them and ultimately create new knowledge, what may collectively be termed 'technological dynamism'. Technological dynamism enables even resource-poor countries to invest their scarce resources effectively, to enter export markets and substitute efficiently for imports, diversify their industrial and export structures and make manufacturing lead to sustained structural transformation. The real difference between the successful industrializers and others lies in this dynamism.

43. The dominant explanation in the current literature is that industrial success (and, by implication, technological dynamism) is due to export-oriented trade strategies. Such strategies are usually taken to involve not just equal incentives to sell abroad as well as domestically but also 'neo-liberal'[31] economic policies: low and uniform protection to domestic industries, free flows of foreign technologies and capital, investment patterns governed by market incentives, the absence of measures to promote local technologies or capacities and unrestrained domestic competition.[32] This interpretation of recent industrial experience leads to strong recommendations for achieving technological dynamism: reduce government intervention, especially in trade, liberalize in respect of direct investment flows, promote competition and so on (generally described as 'getting prices right'). The appropriate role for the Government is then to provide physical infrastructure and set the legal rules of the game.

44. This chapter argues that while export orientation (in the sense of providing neutral incentives between foreign and domestic markets) is desirable, the experience of successful industrializers does not support the minimalist government role prescribed. On the contrary, the most successful industrializers have been dynamic precisely because they intervened heavily in the process of building up technological capabilities. Their interventions were both 'functional' (to strengthen market forces without favouring particular activities) and 'selective' (to promote particular activities or firms over others), though the extent and choice of interventions varied greatly. The nature of interventions needed may vary with the stage of development and national objectives and with the ability of Governments to mount interventions, but the need to intervene remains. This leads to very different policy implications from the undifferentiated solutions now being imposed on a wide spectrum of developing countries.

B. The basis of technological dynamism

45. A country's technological dynamism in manufacturing has many elements. These can be grouped under two headings: first, the capabilities of its individual manufacturing enterprises; and second, the interactions between individual manufacturers and between them and the supporting environment. Firm-level capabilities consist of the skills, knowledge and institutional coherence

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[31] By 'neo-liberal' in this report is meant the view that all markets operate efficiently without government intervention.

[32] The 'liberal' or neoclassical interpretation of the industrialization experience is represented by authors such as Balassa, Krueger, Harberger, Bhagwati and Lal. A good review is given in J. Weiss, *Industry in Developing Countries*, (Croom Helm) London, 1988.

which enable a manufacturer to do three things: first, to identify and engineer viable projects, purchase the relevant technology and capital goods, execute the investment efficiently (or 'investment capabilities'); second, to master the process and product technology, achieve efficient levels of quality, maintenance and operating procedures, adapt the technologies to local materials and customer needs, improve the technology over time and diversify and add to the technological base ('production capabilities'); and third, to establish efficient flows of knowledge and information with suppliers, customers, consultants and science and technology institutions ('linkage capabilities').[33]

46. Some of these capabilities can be acquired by an enterprise 'ready made' from the market. However, many of the skills needed to handle new technologies do not exist in developing countries and have to be acquired by the firm. This entails a conscious (and often prolonged and expensive) process of training, acquiring new information, experimentation and interaction with other agents. Thus, even gaining mastery of a given technology is a 'learning process' in developing countries, requiring effort and expense at all levels of operation.[34] Different firms achieve different levels of efficiency depending on their learning investments, the skills available on labour markets and the support provided externally. Technological mastery shades into improvement and, as the firm matures, into innovation (with formal R and D becoming prominent), but technological dynamism in essence is a process of constant capability building in every aspect of manufacturing activity.

47. As with any investment, investment in capability acquisition is conditioned by incentives arising in the markets facing firms. Two aspects need mention here. First, the macroeconomic environment has strong effects. Stability, growth and a predictable policy structure are clearly conducive to investments in capability aquisition (just as they are to investments in physical capacity). A favourable growth setting also enables greater capability acquisition in a physical sense: enterprises have more opportunities and resources to repeat particular tasks and add to capacity. The 1980s are likely to have been disruptive for technological development for a number of developing countries, apart from the broader stresses they generated (some of these points are taken up below).

48. Second, competition, both domestic and international, provides a powerful stimulant to technological dynamism. However, it is a double-edged sword: the full force of external competition from mature enterprises can prevent new entrants from acquiring a base of capabilities and so retard capability development. This is the 'infant industry' case for providing protection during the learning period. Since protection itself can reduce pressures to invest in capabilities, it has to be temporary (geared to the learning period of the relevant technology), selective (not too many activities are protected at one time and protection is not given to compensate for inefficiencies arising outside the firm, e.g. lack of education or infrastructure), and counter-balanced by incentives to achieve world standards of performance (for instance, by making exporting attractive even when protecting domestic sales). Protection that is excessive, prolonged and not supported by measures to reduce costs external to the protected activity can lead to permanent 'infants' that never mature to competitiveness in world markets.[35]

49. Even given optimal incentive structures, firm-level technological development does not occur in isolation. It entails intense and continuous interaction with the industrial environment, which provides the human and financial resources needed for internal capability development, determines the extent to which firms specialize and so increase their productive efficiency, and supplies such 'public goods' as standards, testing, basic R and D and other forms of institutional support that enable firms to conduct in-house technical work effectively. Thus, national technological dynamism is more than the sum of individual enterprise capabilities: it is the synergy arising from the interaction of enterprises, markets and institutions.

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[33] The constituents of technological capability are further explored in C. Dahlman, B. Ross-Larson and L.E. Westphal, "Managing technological development", *World Development*, 1987, p.759-75; J. Katz (ed.), *Technology generation in Latin American manufacturing industries*, (Macmillan, London, 1987); S. Lall, *Learning to industrialize*, (Macmillan, London, 1987); and S. Teitel, "Technology creation in semi-industrial economies", *Journal of Development Economics*, 1984, p.39-61.

[34] A similar process occurs in enterprises in developed countries, with the important difference that most 'routine' capabilities can be readily hired from the labour market and in firm efforts can concentrate on mastering the more novel, innovative features of technologies. Despite the broad availability of routine capabilities and open, competitive markets, however, individual enterprises in advanced industrial countries also display persistent differences in productivity (i.e. in technological mastery). See R.R. Nelson, "Research on productivity growth and productivity differences: Dead ends and new departures", *Journal of Economic Literature*, 1981, No. 19, p. 1029-64.

[35] The case for selective protection is presented in H. Pack and L.E. Westphal, "Industrial strategy and technological change: Theory versus reality", *Journal of Development Economics*, 1986, p.87-128, and S. Lall "Explaining industrial success in the developing world", in V.N. Balasubramanyam and S. Lall (eds.), *Current issues in development economics*, (Macmillan, London, 1991) (forthcoming). The risks of infant industry over-protection are analysed in M. Bell, B. Ross-Larson and L.E. Westphal, "Assessing the performance of infant industries", *Journal of Development Economics*, 1984, 16, p.101-128.

50. National technological dynamism is thus subject to policy interventions at three points:[36] first, in the *incentive structures* that induce enterprises to build up capabilities, requiring sound macro management and the provision of selective infant industry protection for activities with costly 'learning' periods; secondly, in the development of *capabilities* to respond to incentives, requiring interventions to develop the skill base (education and training), to promote appropriate technology inflows, and to induce domestic R and D activity; thirdly, in supporting a variety of *institutions* to facilitate the functioning of markets, in particular the flow of information and skills and inter-industry linkages. Moreover, it is the complex *interaction* of these three factors that determines technological dynamism: simply providing incentives without building up capabilities or institutions (or vice versa) may be ineffective, even counterproductive. This simplified framework for analysing the process of industrial development yields useful insights into recent experience. It also yields rich policy implications, sometimes quite different from the prevalent 'neo-liberal' orthodoxy.

C. Indicators of technological dynamism

51. The relative industrial and technological performance of developing countries can be gauged in many ways. Table 3 presents several indicators of performance in 29 developing countries and territories for the period 1970-1988. Some of the indicators are subdivided into two periods (1970-1980 and 1980-1988) to show the impact of the debt crisis and terms-of-trade shocks on some of the sample countries. These data need careful interpretation in order to arrive at a meaningful picture of recent performance, partly because there is no unambiguous measure of dynamism and partly because of the effects of the shocks of the 1980s.[37]

52. In terms of the levels of industrialization, the four more advanced countries and territories of East Asia (Hong Kong, Republic of Korea, Singapore, and Taiwan Province of China) have the highest shares of manufacturing in GDP (27 to 43 per cent). They also recorded some of the highest growth rates in manufacturing over the period 1970-1987 (from 8 to 14 per cent per annum), though some of the newly industrializing countries (Indonesia, Malaysia, Thailand) and Tunisia also fall in this range. The complexity of the manufacturing sector, as indicated by the share and growth of capital goods production, is also the highest in East Asia, though Hong Kong is distinctly below the others and is close to Argentina and Brazil. Capital employed per worker has risen fastest in East Asia and showed fairly high values by 1988, but Argentina (with the longest established industrial base), Brazil, Venezuela and Turkey also showed high levels. Productivity growth is consistently high for the Republic of Korea and Taiwan Province of China (data for Hong Kong are only available for the 1980s and are high, while Singapore performed well in the 1980s but poorly in the 1970s). The productivity performance of several other Asian countries (India, Malaysia, Pakistan, Philippines, Thailand, and Turkey) improved significantly in the 1980s, while Latin American and African countries had a relatively weak showing in both periods. The incremental capital output ratio (ICOR) tended to rise in most countries in the 1980s as a result of worsening capacity utilization (India, being a major exception) and/or the rising complexity of manufacturing activities (as in the Republic of Korea and Singapore).

53. Manufactured export performance, as measured by market shares, reveals the strong competitive position of the more advanced East Asian economies. All other Asian countries also recorded increases in market shares in the 1980s, in contrast to most African and Latin American countries. Finally, table 3 gives data on patents taken out internationally. This is a very crude indicator of technological dynamism, since the true economic 'value' of patents is difficult to judge, propensities to patent may differ, and some national patents may in fact be taken out by resident foreigners. Nevertheless, the data (normalised by population) reinforce the impression of dynamism in the more advanced East Asian economies. Some Latin American countries (Argentina and Mexico) also have impressive patent records, testifying to latent capabilities that are not revealed in industrial growth or competitiveness (see below).

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[36] See S. Lall, *Building industrial competitiveness in developing countries*, Paris, OECD Development Centre, 1990.

[37] It may be argued that the extent of the shocks felt by particular countries themselves reflected, at least in part, past industrial dynamism: countries with small or inefficient industrial structures fared worse in the deteriorating international environment.

Table 3

Technological development and related economic performance

29 developing countries and territories by region	Manufacturing value added		MVA [a] in capital goods industry [b]			Capital stock per employee in manufacturing [c]			Productivity [d]		ICOR [e]		World market share in manufactured exports			External patenting [f]	
	Growth	as % of GDP	Growth		as % of GDP	Growth		Value	Growth				% change		%	accumulated 1962-1987	
	1970-1987	1987	1970-1980	1980-1987	1987	1972-1980	1980-1988	1988	1970-1980	1980-1987	1970-1979	1980-1988	1970-1980	1980-1988	1988	No. [g]	No. [h]
Côte d'Ivoire	3.3	9	1.3	2.0	2.1	2	-3	4	-0.4	1.3	3.3	17.2	-0.002	0.006	0.013	4	0.49
Egypt	6.2	11	-0.8	4.2	1.3	11	4	1	2.3	3.3	2.8	2.7	-0.045	0.060	0.076	35	0.84
Kenya	7.6	12	-4.3	-5.6	0.7	0	-1	1	2.1	1.3	5.6	6.2	-0.004	-0.003	0.005	23	1.37
Nigeria	5.2	4	21.0	-17.2	0.7	16	-1	2	0.0	-0.8	5.1	..	-0.013	-0.004	0.003	22	0.27
Tunisia	9.7	14	11.9	4.3	1.8	8	3	3	3.3	2.0	4.2	9.1	0.024	0.011	0.048	13	2.03
United Rep. of Tanzania	0.5	7	6.7	-12.0	0.4	3	-9	1	-3.7	-3.8	6.5	15.1	-0.002	-0.001	0.002	9	0.48
Zambia	1.6	20	5.7	1.7	3.0	..	..	5	-2.0	0.6	44.0	44.0	-0.076	-0.019	0.037	11	1.95
Argentina	0.5	24	-1.3	1.9	7.0	6	-1	10	3.1	2.5	9.0	..	0.017	-0.007	0.083	520	18.71
Brazil	5.7	25	1.8	-0.4	5.7	9	-1	13	1.0	1.3	3.2	7.1	0.250	0.134	0.486	478	3.94
Chile	1.0	21	-6.5	-2.8	1.5	0	-1	7	2.8	2.4	13.4	11.9	-0.021	-0.021	0.109	79	7.10
Colombia	4.6	22	2.3	-1.9	2.0	3	4	6	1.8	4.2	3.1	6.0	0.017	-0.007	0.029	110	4.26
Costa Rica	5.1	19	5.2	-3.1	1.2	..	..	..	..	..	3.8	11.9	0.004	-0.007	0.008	32	14.04
Ecuador	5.8	17	8.0	-1.1	1.4	8	2	4	0.5	1.9	..	..	0.003	-0.002	0.001	33	4.06
Guatemala	3.1	16	-0.1	-5.7	0.5	4	-6	1	1.9	0.1	3.3	..	-0.003	-0.017	0.003	45	6.51
Mexico	4.3	21	1.9	-3.2	2.9	3	3	7	3.6	2.3	3.5	23.1	-0.041	0.147	0.252	1301	18.75
Peru	3.0	21	6.5	-9.0	1.7	3	-2	5	0.1	2.9	6.9	..	-0.006	-0.035	0.037	67	3.87
Uruguay	1.5	22	0.4	-0.1	2.8	0	2	4	3.4	5.5	3.8	..	0.003	-0.002	0.016	..	..
Venezuela	4.1	19	9.2	-0.3	2.2	4	3	11	-2.7	3.6	6.0	41.2	0.018	-0.007	0.027	220	14.64
Hong Kong	13.4	30	..	..	6.1	..	..	..	..	6.7	3.8	4.2	0.590	0.650	1.640	387	76.81
India	5.7	19	1.3	3.2	2.9	3	9	3	0.1	7.6	7.4	3.9	-0.071	0.015	0.237	301	0.44
Indonesia	11.8	17	22.0	7.4	1.1	18	4	2	7.4	-0.5	2.1	6.4	0.041	0.136	0.183	75	0.50
Malaysia	9.9	24	13.8	1.3	3.5	7	10	4	0.9	6.5	3.1	8.0	-0.002	0.070	0.232	74	5.38
Pakistan	6.9	17	2.6	-0.2	0.9	1	9	2	5.0	8.2	3.4	4.0	-0.055	0.024	0.080	15	0.17
Philippines	3.8	24	0.9	-10.8	0.8	-4	1	1	-2.6	5.6	3.5	54.6	0.077	0.031	0.133	132	2.73
Rep. of Korea	13.6	34	9.7	8.7	10.3	15	11	15	5.8	6.9	2.7	4.0	0.543	0.703	1.412	331	8.68
Singapore	8.1	27	8.7	1.9	16.9	11	8	18	1.7	6.5	4.8	8.5	0.362	0.331	0.813	76	31.48
Taiwan Prov. of China	11.2	43	..	..	10.3	..	..	..	11.9	7.7	3.9	4.1	0.497	1.080	1.630	1289	72.40
Thailand	8.4	22	6.1	0.6	3.0	3	8	4	3.4	8.1	3.6	4.7	0.067	0.124	0.236	19	0.41
Turkey	6.7	27	5.6	1.2	2.7	7	6	11	0.9	5.7	4.3	3.1	0.020	0.170	0.206	41	0.92

Source: UNCTAD secretariat computations based on data from UNSO, UNIDO, IMF, OECD, and United States Patent Office.

a Manufacturing value added.

b Capital goods industry defined as output of ISIC 381 to ISIC 385.

c For the computation of capital stock, see notes to figure 1. The values in 1988 are relative values only. They are estimated on the assumption that the share of capital goods in the manufacturing sector is proportional to the share of the manufacturing sector in total GDP.

d Value added per employee in the manufacturing sector.

e Incremental capital output ratio (ICOR) for the period i to j is defined as the ratio of gross fixed investment over the period i minus 1 to j minus 1 to output in period j minus output in period i.

f External patents granted in the United States, accumulated 1962 to 1987.

g Accumulated patents 1962 to 1987.

h Per million population (1980).

D. Explaining contrasting experiences

54. It is difficult, as noted, to provide a complete explanation of recent industrial performance because of the influence of macroeconomic factors discussed in the preceding chapter. Nevertheless, it appears from many indicators that the more advanced countries of East Asia, and to a lesser extent the newly industrializing countries of Asia, manifest greater dynamism than other developing countries. It is this phenomenon that has formed the empirical basis of the current orthodoxy on industrialisation: viz, industrial success is based on neo-liberal incentive structures, as manifested in outward-oriented trade régimes.

55. This school argues that such régimes lead not only to better export performance (i.e. the exploitation of existing comparative advantage) but also to greater technological dynamism (the creation of new competitive advantages). In other words, providing a neutral structure of incentives encourages competitive industries to export. But it does more: it lowers ICORs by enforcing efficient specialization, leads to the realization of economies of scale (in capital-intensive industries), promotes faster and healthier accumulation of skills and technological capabilities, provides an additional (and largely free) channel of information to exporters, and, by easing foreign exchange constraints, permits steadier growth and greater availability of imported equipment, inputs and technologies.

56. These arguments clearly have a lot of validity. Incentives do matter, and specialization by comparative advantage does offer benefits. International competition and contacts with world markets do stimulate technological dynamism and a diversified export base does help steady long-term development. The record of industrialization supports a broad association between export orientation, export growth and industrial development, though the relationship may not hold for all periods or for the degree of export orientation (some 'moderately inward-oriented' countries do better than some 'moderately outward-oriented' ones).[38] The more advanced East Asian economies are the best performers and also the most outward-oriented régimes, and the newly industrializing economies appear set to follow them down the export-based growth path.

57. The lessons that can be drawn from this are not, however, as simple and straightforward as current orthodoxy suggests. 'Export-orientation' does not represent a uniform set of policies, nor does it necessarily carry the neo-liberal connotations noted earlier. There are two major sets of qualifications to this interpretation. The first concerns *incentive structures* in product markets, the second the role of *intervention on factor markets*. These are discussed in turn.

58. A neutral structure of incentives between domestic and export markets can coexist with neo-liberal trade régimes (low and uniform protection) or with highly variable protection for import-substituting activities. Export success may be based on instant entry into world markets, or it may derive from long periods of 'learning' based on serving protected domestic markets (import substitution).

59. The more advanced East Asian economies display a wide range of export-oriented strategies. Hong Kong is the closest to the neo-liberal paradigm: free trade policies from the inception of industrialization. The Republic of Korea is at the other extreme: a high degree of selective intervention (to pick and promote 'winners', especially in heavy and high-technology activities) and high rates of protection sustained for long periods for new activities offset by export incentives, combined with low protection for mature industries.[39] Singapore had an initial period of import substitution followed by liberal trade policies. Taiwan Province of China was closer to the Republic of Korea, with selective and often high rates of protection; however, it was less interventionist in promoting heavy industry.

60. Each of these economies is successful and competitive, yet the resulting industrial structures are vastly different. Hong Kong remains specialized in light consumer goods, with a high reliance on foreign technology and inputs; its industrial structure has little depth or innovative capability and is, therefore, vulnerable to rising costs. It has survived by rapidly shifting its manufacturing offshore, mainly to China, because it could not diversify into more complex activities at home. By contrast, the Republic of Korea has built up a diversified industrial base, with a range of effi-

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[38] See the World Bank's *World Development Report*, New York, Oxford University Press, 1987

[39] This form of export-orientation is analysed in detail for the case of the Republic of Korea by L.E. Westphal, "Industrial policy in an export-propelled economy: Lessons from South Korea's experience", *Journal of Economic Perspectives*, 4:3, 1990, pp.41-59.

cient heavy and technology-intensive industries, a high degree of local integration and well-developed local design and innovation capabilities. The *chaebol* (diversified business groups) of the Republic of Korea are investing abroad mainly in sophisticated activities to serve local markets (mainly in developed market-economy countries), while upgrading domestic activity to cope with rising wages. Singapore has entered into much heavier industry than Hong Kong by intervening in the direction of investment flows rather than via protection, but its product range is narrow and its technology is entirely provided from abroad by transnationals that dominate its manufacturing.[40] The industry of Taiwan, Province of China, has a diversified structure, but is smaller in scale and less capital-intensive than the Republic of Korea's: the former's strategy has been more incremental and less aimed at large leaps into heavy industry than the latter. Taiwan, Province of China, like Hong Kong, has moved low-tech small and medium-sized enterprises to China, instead of increasing the scale or capital intensity of enterprises at home. It is the Republic of Korea that has come closest to emulating the Japanese strategy, and it is indisputable that it was only its massive interventions, within an export-oriented framework, that made this possible.[41]

61. While export-orientation is compatible with interventions in incentive structures, the form of interventions differs significantly from interventions as practised in inward-oriented economies. The two key differences lie in *selectivity* and *offsetting safeguards*. The two larger East Asian NIEs did not give widespread, protracted, haphazard protection to all industrial activities started in their markets. They promoted a few new activities at any given time, letting mature activities operate effectively in a free trade régime; they geared protection to the 'learning' period involved and forced firms to enter export markets as soon as possible to reap the competitive benefits of world exposure; and the overall incentive structure always favoured exports.[42] By contrast, most inward-oriented economies promoted industries by means of high, haphazard and widespread protection, giving net disincentives to exporting and sustaining activities regardless of their efficiency. It was not intervention (and protection) *per se* that was wrong, but the particular interventions utilized: the export-oriented interveners were truly selective, while the inward-oriented interveners were largely unselective and failed to offset the effects of protection. Moreover, in the field of macro-economic policy, an additional disincentive to exports was provided by large fluctuations in the real exchange rates. Since some of the countries which adopted inward-oriented development strategies were characterized by high inflation rates, the real exchange rate was often too high and thus prohibitive to exporters.[43]

62. The second major qualification to the neo-liberal view on export orientation concerns the role of *government interventions in factor markets*. These are portrayed as being minimal and non-selective. This interpretation is unwarranted. Each of the Governments of the more advanced Asian countries intervened in a sustained manner to develop the capabilities and institutions necessary for technological dynamism. Some of this intervention was non-selective (or functional); some was highly selective, aimed at promoting the growth of particular activities, particular capabilities, even particular enterprises.

63. This is illustrated in table 4 for the sample countries with reference to the major components of national technological dynamism identified earlier: human capital or skills, imports of technology and domestic technological effort (institution-building cannot be measured so is ignored for the present). Table 4 also shows the rate of investment in plant and equipment in manufacturing in the 1970s and 1980s. While such investment is governed to a large extent by macroeconomic and exogenous factors beyond the concerns of this report, it forms one of the necessary conditions for industrial growth (the data shown are of particular interest because they are not calculated elsewhere).

64. The more advanced and the newly industrializing countries of Asia had among the highest increases (during the period 1972-1988) of equipment investment in manufacturing, and evidently used it with the highest rates of efficiency. What the data do not show is the role of government intervention in channelling those investments. With the exception of Hong Kong, each of the

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[40] See L.B. Krause, "Hong Kong and Singapore: Twins or Kissing Cousins?", *Economic Development and Cultural Change*, 1988, 36:3, pp.45-66.

[41] See P.W. Kuznets, "An East Asian model of economic development: Japan, Taiwan and South Korea", *Economic Development and Cultural Change*, 1988, 36:3, p.11-13, and R. Wade, "The role of government in overcoming market failure: Taiwan, Republic of Korea and Japan", in H. Hughes (ed.), *Achieving Industrialization in East Asia* (Cambridge University Press, Cambridge, 1988).

[42] See Pack and Westphal (*op.cit.*) and Westphal (*op.cit.*) on the Korean strategy.

[43] On the subject of exchange rates and export performance, see chapter V, "Trade policy reform and export performance in developing countries in the 1990s" in UNCTAD, *Trade and Development Report, 1989* (United Nations publication, Sales No. E.89.II.D.14), New York, 1989.

Table 4

Investment in technology and skills

29 developing countries and territories by region	Total capital stock [a] 1980 = 100		Technology inflows as % of GDI [b]			Human resources 1987 or closest available year				Research and development expenditure (latest available year)	
							Educational enrolment				
			MCG [c]	FDI [d]	TC [e]	Literacy rate %	At 2nd level as % of age group	Per 100,000 population: Science and technology 3rd level [f]	Per 100,000 population: Vocational training 2nd level	Total as % of GNP	Of which the productive sector as % of GNP
	1972	1988	1975-87	1975-87	1975-87						
Côte d'Ivoire	43	73	26.2	3.6	4.0	43	18	27	249	0.3	..
Egypt	26	184	62.0	14.6	6.4	44	69	167	1833	0.2	0.039
Kenya	56	103	30.2	2.1	7.3	59	21	22	25	0.8	..
Nigeria	22	74	18.2	3.4	0.3	42	29	24	98	0.3	..
Tunisia	28	133	28.4	5.6	3.0	51	40	126	1225	..	..
United Rep. of Tanzania	42	68	20.8	0.6	11.3	46	4	3	..	..	..
Zambia	78	87	42.3	7.1	8.2	76	17	18	38	0.5	..
Argentina	67	76	8.1	2.0	0.1	94	74	363	3834	0.4	0.179
Brazil	35	100	8.7	3.5	0.1	78	38	160	1092	0.4	0.268
Chile	96	88	21.5	3.8	0.9	91	70	538	1062	0.5	0.211
Colombia	56	119	20.4	9.5	0.9	85	56	387	1515	0.1	0.002
Costa Rica	49	92	20.9	6.9	3.4	93	41	312	981	0.3	0.000
Ecuador	29	101	26.3	2.8	4.6	80	56	636	2624	0.5	..
Guatemala	55	64	18.1	8.1	2.4	46	20	..	430	0.6	..
Mexico	61	111	21.0	3.5	0.1	90	53	453	1051	0.6	0.173
Peru	54	78	17.3	0.2	1.7	82	65	563	297	0.2	..
Uruguay	69	74	13.2	0.4	1.0	95	73	379	1359	0.2	..
Venezuela	38	96	22.6	0.6	0.1	85	54	558	304	0.3	..
Hong Kong	..	..	39.0	7.0	0.1	77	72	318	800	..	..
India	63	165	8.6	0.2	0.4	41	35	..	80	0.9	0.191
Indonesia	26	177	17.2	1.5	1.1	67	39	16	626	0.3	..
Malaysia	33	167	34.9	9.0	0.8	70	59	85	122	..	..
Pakistan	80	165	20.4	1.3	2.4	26	18	28	51	0.4	0.327
Philippines	62	71	29.3	1.5	1.1	83	64	770	..	0.1	0.023
Rep. of Korea	21	239	25.7	0.9	0.1	88	89	765	1970	2.3	1.543
Singapore	25	169	88.4	16.8	0.3	83	69	704	372	0.9	0.521
Taiwan Province of China	..	..	33.2	3.3	..	92	91	795	2082	1.1	0.738
Thailand	49	147	23.6	3.0	1.4	79	30	..	648	0.3	..
Turkey	44	156	25.0	0.8	0.5	74	46	222	1402	0.7	0.532

Source: UNCTAD secretariat computations based on data from UNIDO, UNSO, UNCTC, OECD and UNESCO.

a See figure 1 for the calculation of capital stocks.

b Gross domestic investment.

c Capital goods imports.

d Foreign direct investment.

e Technical co-operation grants.

f Third-level students in natural science, mathematics and computer science, engineering, and transport and communications.

more advanced East Asian economies influenced resource allocation in industry. Singapore directed FDI inflows into more high-value-added, high-tech activities. Taiwan Province of China used tariffs to influence investment, as well as directly taking the public sector into heavy industry and providing various inducements (such as joint ventures and science parks) to attract private industry into areas of future competitiveness. The Republic of Korea intervened most heavily of all through its import-substitution programmes (accelerated in the 1970s in the 'Heavy and Chemical Industries' drive), its allocation of credit via the State-controlled banking system, its promotion and subsidisation of selected private businesses into giant conglomerates (the *chaebol*) to lead its heavy industry drive, its close direction of activity and exports in the business sector, and some public sector industrial investments (its famous Pohang steel mill). The *chaebol* strategy was clearly not free competition in the traditional sense, since entry and growth were controlled by the Government (although the giants competed fiercely with one another).

65. The domestic production of capital goods has a special significance for technological dynamism because of the central role of machinery manufacture in generating and diffusing technology. However, the promotion of local equipment manufacture runs the risk of creating technological lags if designs and performance are not up to world standards. The correct balance between making and buying capital goods is thus important for long-term industrial dynamism and competitiveness. The most successful countries, such as the Republic of Korea, have promoted local equipment manufacture selectively, while importing large amounts of foreign equipment to retain export competitiveness. Some, like Argentina, Brazil or India, have pursued stringent import-substitution in capital goods, thus creating a broad domestic capability in design and manufacture but risking the competitiveness of user industries. Others, like most sub-Saharan African countries, have low domestic equipment manufacturing and rely largely on foreign capital goods. However, their low levels of skills and technological ability (see below) have reduced their ability to deploy their capital stocks efficiently. The ability to import of many Latin American and African countries has, as noted in chapter I, suffered from recent economic shocks: this has probably led to a deterioration not just in the stock of productive capital but also in its modernity and quality.

66. The accumulation of physical capital in manufacturing cannot be efficient if it is not accompanied by the creation of new skills, the import of new technologies and the launching of domestic technological effort. The skills needed for industrialization are diverse. At the lowest level, literacy helps the labour force to be productive and is an important determinant of labour productivity in very simple industries. Secondary education, and in particular vocational training, become increasingly important for shopfloor skills as industry grows more complex. Tertiary-level skills, especially in science and engineering fields, are needed for all industries, but they increase sharply in significance with growing industrial complexity.

67. The more advanced East Asian economies in general have invested intensively in recent years in creating the skill base needed for technological dynamism,[44] and this is a vital ingredient of their dynamism. However, three important points have to be noted here. First, some other developing countries have also invested heavily in human capital (particularly in Latin America, the Philippines, Egypt, and Turkey). Since it is the interaction of human resources with incentives, physical investment and technological effort that drives technological dynamism, the mere possession of skills is a necessary but not sufficient condition for success. Other countries with ample human resources may have suffered from inappropriate incentive structures, inadequate technological effort or institutional weaknesses. This point is borne out more strikingly by the record of Eastern Europe, where there has long existed an ample stock of human capital and technical skills. Yet distorted incentives, combined with institutional weaknesses and isolation form world technologies, have led to very poor industrial performance.

68. Secondly, there are important differences between the more advanced East Asian economies. The two larger ones have a broadly stronger skill base than the smaller economies. Hong Kong appears weak in high-level technical skills and Singapore in vocational training.[45] This difference reflects the drive of the two larger economies into technologically demanding activities, as well as high skill inputs into their mature industries. Some other countries (like Brazil and India) have even more complex, heavy industrial structures but have developed lower skill bases: the result is probably lower efficiency. Thirdly, educational enrollment figures have to be corrected for vari-

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[44] Even by the 1960s, the East Asian NIEs had among the best developed human resources in the developing world, though some Latin American countries (like Argentina, Uruguay, Chile and Venezuela) also had substantial bases.

[45] It should be noted, however, that Singapore's vocational training figures may be misleading because it has a large programme for post-employment worker training, regarded as one of the world's best. However, such worker training is likely to provide more specialized skills than vocational training and may be less suited to the diverse industrial structures of larger countries.

ations in dropout rates, overseas education, quality of training and relevance of curriculum content to make them fully comparable. This is not always possible, but it is likely that such corrections would increase the observed lead of East Asia.[46] The data also exclude employee training by firms: here the Republic of Korea (with 5 per cent of sales of all larger firms required to be invested in training) is likely to lead the other sample countries.

69. The growth of human resources for industrialization has been an essential precondition for export success, and it has not been caused by neutral incentives. The 'education market' has required heavy intervention to provide the level, quality and technical orientation of the resource base. This point is strengthened if in-firm worker training is taken into account: firms tend to underinvest in such training when there is a risk of leakage (workers moving to other firms) and Government support is needed to ensure adequate investments. Human resource interventions have been partly functional, to create general skills, and partly selective, to create the particular skills needed by the activities being promoted by the Government. Education markets do not function efficiently, especially in developing countries,[47] but neo-liberal economists (while they may accept the need to boost education) tend to ignore the critical role of such intervention in the context of industrial policy and experience. While human resources may not be the binding constraint in the industrialization of some (mainly Latin American) countries, they do constitute major impediments to industrial development in others (mainly in sub-Saharan Africa).[48]

70. Technological effort and imports are also essential ingredients of technological dynamism. To a large extent, they complement each other. Developing countries need to import a great deal of embodied and disembodied technology; they also need to do a lot themselves to absorb it and build upon it. Technology imports in the form of capital goods are the most accessible but require the greatest local capabilities and efforts to operate efficiently. Most complex technology transfers also need disembodied transfers of know-how, training, patents and the like; these are available via FDI, licensing or other forms of contractual arrangement. International technology markets can be fragmented and oligopolistic and may call for official intervention to strengthen the informational and negotiating position of developing country buyers. They are, however, fairly open to all developing countries, with two qualifications: first, the more advanced, export-oriented enterprises may find it difficult to buy state-of-the-art technology at arms' length because of the competitive threat they pose (the leading *chaebol* in the Republic of Korea now have to develop many of their own new products because of the reluctance of technological leaders to license them). Secondly, some new technologies are very expensive to create and are being held more tightly than were earlier technologies. There is also a growing propensity, as noted in chapter I, for leading innovators to form 'strategic alliances' in developing new technologies. These tendencies raise the cost of entry to all newcomers, in developed or developing countries.[49]

71. Different forms of technology imports have differing implications for technological development. FDI may be a very effective means of transferring rapidly the results of new innovations as they appear. It may not, however, be equally effective in transferring innovative capabilities: transnationals generally find it economical to centralize R and D in developed countries with an ample skill base and established linkages with a highly advanced science and technology infrastructure. Thus, the building up of local innovative capabilities may require the promotion of indigenous firms and selective restrictions on FDI inflows. Experience shows that countries with technological ambitions have indeed been selective in allowing FDI at critical junctures. The Republic of Korea is again a case in point. It has the lowest reliance on FDI of all the NIEs despite its advanced industrial structure, making up the gap with its own intense technological effort (see below) and the promotion of *chaebol*, which are large and diversified enough to bear the cost and risk of entry into high-tech activities.

72. Heavy reliance on FDI does not stifle industrial growth; it may only reduce the indigenous technological content of industrialization. On the other hand, simply restricting FDI without providing the incentives or skills to develop local technologies can be very counterproductive, leading to inefficiency and obsolescence. If this is combined with restrictions on other forms of

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[46] See Lall, 1990, *op.cit.*, pp.47-48. The East Asian NIEs have substantial numbers of tertiary students registered in foreign universities. For instance, Hong Kong has 24,700, Singapore 8,900 and the Republic of Korea 29,400 compared to Argentina 3,100, Brazil 6,700 and Mexico 8,200.

[47] The debate over skill gaps in the United states and the United Kingdom suggest, moreover, that they do not always function perfectly in mature, open economies either. See, for instance, OECD, *Structural Adjustment and Economic Performance*, Paris, 1987; Office of Technology Assessment, *Making Things Better*, Washington, D.C., 1990.

[48] On the role of education and skills in constraining African industrialization, see S. Lall, "Structural problems of African industry", in Frances Stewart, S. Lall and S. Wangwe (eds.), *Alternative Development Strategies for Africa*, (Macmillan, London, 1991) (forthcoming).

[49] D. Ernst and J. O'Connor, *Technology and global competition: The challenge ahead for newly industrializing economies*, Paris, OECD, 1989.

technology inflows and high inward-orientation, the costs can be compounded -- as happened in India in the 1970s.[50]

73. The import of technology by successful industrializers like the Republic of Korea has been subject to considerable interventions by the Government. In turn-key projects, the Government has insisted that local engineers participate in all stages of design and engineering. In licensing, local firms were provided with information and assisted with bargaining. 'Reverse engineering' was encouraged and intellectual property laws were liberally applied and weakly interpreted (as in Taiwan Province of China): this followed the earlier model of Japan.[51] Interventions with technology transfer were non-existent in Hong Kong and Singapore, though the latter (as noted) strongly guided the nature and sophistication of FDI inflows.

74. Technical assistance inflows are mainly used by countries with low industrial capabilities and limited recourse to other forms of technology transfer. The experience of technical assistance has not been a happy one, especially when (as in sub-Saharan Africa) absorptive capacities are low and it is difficult to monitor the content of technical assistance. In these circumstances, technical assistance can become a substitute for local capabilities rather than a complement. It can also lead to poor selection of projects that do little to develop industrial competitiveness.

75. Formal R and D efforts are shown in the last two columns of table 4. Total R and D figures include agricultural, defence, construction and other forms of effort, but it is not possible to obtain manufacturing R and D data on a comparable basis for all sample countries. The nearest approximation is R and D in the 'productive sector' (which includes agriculture); this is also shown where available. The Republic of Korea leads the field by far, testifying to the needs and capabilities generated by past policies to diversify and deepen industry. The bulk of the Republic of Korea's R and D, currently the highest in the developing world, emanates from its *chaebol*, themselves the result of highly selective intervention. Taiwan Province of China comes next, followed by Turkey and Singapore. Brazil's R and D has dropped sharply since the early 1980s, presumably because of debt-induced problems, while Argentina, despite its human resources, spends little on productive sector research.

76. Finally, although this cannot be established quantitatively, the successful industrializers have invested heavily in setting up industrial support institutions, especially to promote technological activity and export marketing. Many other countries have also set up complex institutional networks, but it is the combination of export-oriented incentives and high levels of skill that has enabled the more advanced Asian economies to set up more effective institutions and exploit them better. Again, widespread and selective interventions were needed to set up the institutional support structure.

E. Implications of past experience

77. Chapter II has shown that technological dynamism cannot be explained by partial theories that stress selected aspects of the incentives-capabilities-institutions nexus. In particular, the neo-liberal interpretation, relying heavily on 'getting prices right' in a supposedly efficient market setting, has ignored the role of capabilities and institutions. It has also underemphasized the positive role of interventions, especially selective interventions, in providing correct incentives and developing the technological capacity to respond to those incentives.

78. While interventions are necessary for sustained industrial development, however, not all interventions are efficient or desirable. Development experience is replete with cases of uneconomic interventions. Excessive, haphazard protection has bred not technological dynamism but many 'infant' industries that have never matured. The setting up of heavy industrial structures without providing an adequate skill or institutional basis has often led to inefficiency. Creating skills without proper incentives has wasted human resources. On the other hand, 'getting prices right' without offering infant industry protection or institutional or skill back-up has sometimes led to industrial stagnation. The secret of success has been in combining incentives with adequate capabilities and institutions, each supported by a proper mix of selective and functional interventions. With the benefit of hindsight, one must also not overlook the influence of external factors which, on the whole, were less constraining on policy options in the 1970s than they are today.

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[50] Lall, *Learning to industrialize*, *op.cit.*

[51] See Alice Amsden, *Asia's Next Giant: South Korea and Late Industrialization*, Oxford University Press, New York, 1989.

Chapter III

CONCLUSION

79. A mixture of success and failure characterizes the technological development experience of developing countries in Africa, Asia and America. Recent history shows that progress in these countries will continue to be determined by a combination of domestic and external forces. Under the influence of structural adjustment programmes, economic policies have been liberalized so as to increase the role of the price mechanism in allocating resources more efficiently. At the same time, efforts by developing countries to attract foreign direct investment and transfer of technology have intensified. But one cannot avoid reiterating the fact that, without decisive steps by the international community to relieve the pervasive effects of excessive debt, the absence of external bank lending and weak commodity prices, risk-averse domestic and foreign enterprises will continue to hold back their spending on the introduction of new products and processes in the industries of these countries and foreign direct investment and transfer of technology will remain stagnant. Even if the international community produces a workable package of measures to deal with the external financial and other dimensions of the slack economic performance of most developing countries, the cumulative effects from the past of reduced investment in technology are likely to affect future economic growth and therefore dampen the prospects for an acceleration of the inflow of technology in the near future.

80. The trade impact of global technological advances varies between raw materials and manufactures. Their depressing effect on raw materials demand makes it doubtful that the expected improved growth of raw materials exports from developing countries during the 1990s will regain the pace set in the 1970s. On the other hand, such advances (primarily in computer technologies) have not had and are unlikely to have during this decade the negative impact on manufactured exports of developing countries predicted by experts. There is a strong possibility that the cost of technology in some sectors for developing countries will increase as a result of the tendency towards technological alliances and recent trends in intellectual property rights enforcement and competition legislation in developed market-economy countries. However, this may be offset by other forces that are diversifying the sources and driving down the cost of technology.

81. Turning to the realm of international trade policy, there is no doubt that progressive trade liberalization and elaboration of disciplines governing trade relations have strong implications for the technological development prospects of developing countries in the 1990s. A positive outcome that takes adequate account of their developmental, trade and technological needs would, by reversing the present tide of protectionism and managed trade, secure greater market access for their exports and, at the same time, have a dynamic impact on their access to technology and on industrial and technological development. The interplay between exports and access to technology points to the fact that participation in trade is an instrument for improving mastery of technology and that, at the same time, the ability to export is not possible without the acquisition of technology. The dynamics of trade and industrialization have a bearing on the development dimension of a number of technology-related trade reforms that have been under consideration in various fora. In particular, the developmental contribution of whatever intellectual property régime is in place during this decade will be dependent on the extent to which it is sensitive to the varying levels of technological capacity. While the possible elimination of investment measures, such as export and local content requirements, might help to eliminate trade distortions, its impact on access to technology and the strengthening of local capacities will be influenced by the policy options that will be open to developing countries in negotiating with foreign investors. The availability of leeway to developing countries to take measures to upgrade the technological capacity of their fledgling service industries will help to determine whether they can become competitive in the international market and the extent to which they are able to accept commitments to liberalize access to their domestic markets for services.

82. Quite apart from the preceding issues, the resolution of other international trade policy issues, such as market access for exports, dumping and countervailing measures and safeguards, will have a strong indirect influence on transfer and development of technology in the years ahead. The boost to exports arising from elimination of the panoply of restrictions and trade harassments that have proliferated in recent years could increase the volume of resources available for investment in new technology in developing countries and expose a greater number of their manufacturing enterprises to the necessity of adapting their processes and products to the rigours of competition. For this to happen, they will need the freedom (following the principle of differential and more favourable treatment) to intervene selectively with measures that promote the techno-

logical dynamism of their infant industries without being forced to make reciprocal concessions to their developed country partners.

83. Governments of the most successful industrializers, the more advanced East Asian countries, have all involved themselves actively in support of industrialization. However, one of the arguments of this report has been that not all interventions are efficient and desirable for fostering dynamism. The policies and supportive measures of the poor performers have often been indiscriminate, which suggests that the future pattern of interventions be changed so as to pay closer attention to market signals. As markets and capabilities develop, the need for interventions declines and the feasibility and mix of policy options changes.

84. In so far as developing country Governments are expected to play a role in guiding the technological transformation of their economies, a re-direction of structural adjustment programmes is called for in order to restore spending on basic infrastructure, training, R and D, information systems, standardization and quality control and other activities that form a part of the framework of incentives to enterprises to invest in new technologies. Related to this is the need for greater caution than at present to ensure that reforms to improve efficiency, such as liberalization of imports and the 'rehabilitation' and restructuring of the enterprise sector, are consistent with the longer-term development objective of stimulating technological dynamism and international competitiveness.

85. The stagnation of technology flows to developing America and Africa suggests the need to explore possible initiatives for revitalizing these flows and stimulating technological co-operation during the 1990s. A new look could be taken at mechanisms for the promotion of such co-operation. In this context, further action in developed countries might be envisaged for encouraging technology transfer to developing countries, for example tax incentives (e.g. greater possibilities for offsetting losses on investments in developing countries against home country tax liabilities), investment guarantees, and concessional credit for technology transfer (including liberalized credit guarantees on machinery exports). Secondly, consideration could be given to possible measures for encouraging non-commercial forms of enterprise-to-enterprise co-operation in training of engineers, technicians and R and D personnel, either on-the-job or on an exchange basis. The formation of economic groupings among industrialized countries may give an impulse to nearly dormant efforts for increased co-operation among developing countries and their enterprises. The time may be ripe to give renewed consideration to such schemes, especially those involving foreign direct investment, joint R and D and scientific and technical co-operation with other economic groupings.